National Defence / Défense nationale

INVESTIGATION OF THE REQUIREMENT FOR AUXILIARY HEATING OF CANADIAN FORCES PERSONNEL

by

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ABSTRACT

In order to investigate the requirement for auxiliary heating by the Canadian Forces, a questionnaire was administered to approximately 1500 CF personnel with experience working outdoors in cold weather. In addition to analyzing the respondents' actual replies, the authors also interpreted the completed questionnnaires regarding the need for auxiliary heat. It was concluded that auxiliary heating would be beneficial to more than 50% of personnel with problems associated with working in the cold and that most of these problems were due to cold extremities (hands and feet).

RÉSUMÉ

Afin de déterminer s'il y a lieu que les Forces canadiennes assurent un service de chauffage auxiliaire, on a distribué un questionnaire à environ 1500 membres des FC ayant déjà travaillé dehors par temps froid. Par l'analyse des réponses, les auteurs du questionnaire ont cherché à établir la raison d'être d'un tel service. Ils ont conclu que le chauffage auxiliaire faciliterait les choses à plus de la moitié de ceux qui ont de la difficulté à travailler dans le froid, et que la plupart des problèmes sont causés par la refroidissement des extrémités (mains et pieds).

INTRODUCTION

In the past, various auxiliary heating devices (handwarmers, electrically-heated gloves and socks, etc.) have been assessed for potential application in military operations in cold weather. Many of these assessments have been ad hoc trials of items "off-the-shelf" which, because of the design, physiological factors, or special military requirements involved, were poorly suited to the needs of the military. Certain delegates at NATO R&D conferences have shown a continuing interest in the potential of auxiliary heating, and a continuing concern that a systems approach be employed to provide better equipment and a better understanding of the applications and limitations of auxiliary heating.

Since a systematic compendium of the relevant data was not available, Canada was asked to draft a Standardization Agreement (STANAG) on the subject. As a result, the Directorate of Clothing, General Engineering and Maintenance (DCGEM) tasked the Environmental Protection Section (EPS) of DREO to provide DCGEM with feasibility studies of the potential applications of auxiliary heating of cold-stressed personnel.

As a first approach to the feasibility study, it was decided that a questionnaire be designed and administered to a cross section of Canadian Forces personnel who had either current or past experience working outdoors in cold weather. One part of the questionnaire (Question 7) specifically asked for information regarding possible uses of auxiliary heating of the hands and feet. This paper reports the results of the analysis of this part of the questionnaire as well as the authors' interpretation of the needs of each respondent for auxiliary heating (as indicated by the answers from other parts of the questionnaire). The answers obtained from the other parts of the questionnaire have been stored on computer discs for use as a bank of information relating to general problems encountered with protective clothing and equipment in the cold. This questionnaire was administered to approximately 1500 CF personnel from all elements - land, sea and air.

METHODS

The questionnaire which was used to gather information on problems caused or aggravated by the cold during military operations is attached as Appendix 1. Appendix 1 differs from the original questionnaire

in that spaces for writing responses have been eliminated. On DREO's behalf, the Director General Land Engineering and Maintenance (DGLEM) asked for assistance and support from Mobile Command, Air Command, Maritime Command, CF Communications Command and CF Europe Headquarters in the administering of the questionnaires and in visiting selected bases. The following bases were visited:

CFB Halifax
CFB Trenton
CFB Comox
CFB Winnipeg
CFB Greenwood
CFB Bagotville
CFB Cold Lake
CFB Namao
CFS Inuvik
St. Margaret's (S.I.T.U.)

During the visit to CFB Halifax, the questionnaire was administered to personnel on board both HMCS Skeena and HMCS Athabaska.

Mobile Command suggested that a good cross section of CF personnel with experience in cold weather operations would be available during Exercise RV83 at CFB Wainwright. Two of the authors attended this exercise to administer the questionnaire. Additional questionnaires were distributed for subsequent completion at the home bases of other personnel. As a result, replies were received from the following:

CFB Wainwright
CFB Gagetown
CFB Chilliwack
CFB Kingston
CFB Calgary
CFB Petawawa
CFB Victoria
CFB Shilo
Quebec Citadel

In addition, questionnaires were sent to and replies were received from CFS Alert. No questionnaires were sent to Europe since the CF Europe reply to DGLEM stated "conditions in Lahr and Baden-Soellingen rarely equate to cold weather in Canada".

Normally, before the administration of the questionnaires, a briefing was held in which one of the authors discussed and explained each question in the questionnaire to the respondents. If none of the authors could attend the briefing, a prepared sheet was read aloud to those answering the questions (Appendix 2).

In the questionnaire, the question dealing with auxiliary heating appears as follows:

Would the addition of auxiliary heating to your clothing or equipment (e.g. methods of heating hands, face, feet, etc.) have helped you to overcome this problem?

If so how?
If not why?

Preliminary analysis of this question indicated that there was a certain amount of confusion as to the meaning of auxiliary heat. For example, some replies to Question 6 ("Describe the measures taken by you presently to accomplish the task/activity:") included the use of "Hot Shots" (a commercial handwarmer) and other types of auxiliary heat, but when Question 7 was answered the corresponding replies were sometimes negative or left blank. Thus, in addition to the actual replies given, each questionnaire was read carefully to determine if, in the authors' opinion, a need for auxiliary heating of some type was indicated. These opinions as well as information regarding the task and base of each respondent was also included in this analysis.

RESULTS AND DISCUSSION

A total of 1498 questionnaires was answered and returned to DREO for analysis. Of these, only 1047 were completed sufficiently to be interpreted as to type of work, problems encountered, clothing worn and environmental conditions. Replies were received from all ranks between private and colonel, from 22 different bases and from personnel performing 30 different tasks. Individual bases are listed in Appendix 3 and a list of the different tasks is given in Appendix 4. Respondents' replies to the various parts of Question 7 were categorized as shown in Table 1.

Analysis of the answers to the question "Would the addition of auxiliary heating of your clothing or equipment have helped you overcome this problem?" indicated that five different answers were given: yes, yes and no (e.g. "Electric gloves would keep my hands warm but would be too dangerous."), no, confused, and no answer. Histograms representing the responses to this question are shown in Figures 1 and 2. Answers are shown as a percentage of the total answers at each base (or task). The numbers at the top of each group of columns indicate the total number of answers received.

It can be seen in Figures 1 and 2 that just under 50% of the respondents indicated "yes", that they would like some form of auxiliary heating. There was, surprisingly, little difference in the percentage of "yes" answers between the designated tasks; however, a slightly higher

percentage of "yes" answers was given by those working in relatively immobile situations such as sentry duty. It can also be seen in Figure 1 that, not surprisingly, there were more "yes" answers at a cold base such as Winnipeg (52%) when compared to a relatively warm base such as Comox (22%).

Histograms representing the analysis of the answers to the question "Which areas would be helped by auxiliary heating?" are shown in Figures 3A, 3B, 4A and 4B. These answers are shown as a percentage of the number that replied "yes" to the previous question. ("Would auxiliary heating help?"). It can easily be seen that the majority of those responding said that the area most helped would be the hands (19%). The feet are the next most important areas in need of auxiliary heat (4%) with other parts of the body not considered to any great extent. There was no clear indication that the distribution of responses varied with task or the base where the task was performed.

The distribution of responses to the questions "If auxiliary heating would help, how?" and "If auxiliary heating would not help, why?" is presented in Table 1. It can be seen that the number of not applicable answers (65% and 71%, respectively) far outweighs the number of responses in the other categories, indicating that either the respondents did not understand these questions or could not think of an answer. The former is probably the more likely since in many cases the need for auxiliary heating was expressed in answers to other questions where there was mention of "Hot Shots" (a commercially-available chemically-powered hand warmer) or some forms of electrical heating. It can also be seen that many do not want auxiliary heating because it "would be a safety hazard". This answer came mainly from refuellers and ground crew who were evidently thinking of possible sparks from electrical heating.

As discussed above, because of the various problems that the respondents had in interpreting the auxiliary heating question, each questionnaire was read carefully to determine if, in the authors' opinion, a need for auxiliary heating was indicated. If auxiliary heating was needed these interpretations were divided into five different categories as follows:

- Electrical axuiliary heating would help;
- Chemical auxiliary heating would help;
- Hot air auxiliary heating would help;
- Infrared auxiliary heating would help;
- Other auxiliary heating would help.

Results are shown in the histograms in Figures 5 and 6. It can be seen that the number of personnel for whom auxiliary heat would be beneficial is much higher than is obvious from their answers to the questionnaire. Much of this is due to the fact that some of the problems indicated in the response to Question 7 can be resolved. For instance if electrical auxiliary heat is a safety hazard, other means of providing non-hazardous auxiliary heat (chemical, infrared, etc.) might be used. Similarly, "being bulky", "adding too much weight", "couldn't work while

TABLE 1

Analysis of Responses to Question 7

If auxiliary heating would help, how?

Would keep body warm and improve efficiency	-	87 (5.8%)
Would be able to work faster	-	44 (2.9%)
Would be able to keep hands warm	-	116 (7.7%)
Would be more comfortable	-	59 (3.9%)
Wouldn't have to leave job to get warm	-	62 (4.1%)
Would be more able to concentrate on work	-	29 (1.9%)
Electric socks keep feet warm	-	11 (.7%)
Would allow faster recovery time once cold	-	13 (.9%)
Would improve manual dexterity	-	22 (1.5%)
Would keep hands and feet warm	-	25 (1.7%)
Heaters in vehicles	-	22 (1.5%)
Not applicable (or no answer)	-	982 (65.6%)

If auxiliary heating would not help, why?

Must remove gloves to work	-	37 (2.5%)
Couldn't work while wearing auxiliary heat	-	22 (1.5%)
Don't need auxiliary heat	-	76 (5.1%)
Wet, not cold is the problem	-	36 (2.4%)
Would restrict movement, be too bulky	-	95 (6.3%)
Would be a safety hazard	-	70 (4.7%)
Would cause more problems than it solved	-	32 (2.1%)
Sweat too much already	-	15 (1.0%)
Would give false sense of security	-	13 (.9%)
Not practical	-	13 (.9%)
Would add too much weight	-	22 (1.5%)
Not applicable (or no answer)	-	1067 (71.2%)

Total number of questionnaires analyzed - 1498

wearing auxiliary heat", etc. were not considered to be insurmountable reasons for not providing auxiliary heat. If auxiliary heat would be beneficial, then the above-mentioned problems should be able to be solved.

Again Figures 5 and 6 indicate that there appears to be little difference in the benefits of auxiliary heating between the designated tasks. It also appears that the requirements for auxiliary heating are slightly greater at cold bases than at warm bases.

CONCLUSIONS

In a survey of CF personnel having experience in cold operations, about 50% of those who responded to a question concerning auxiliary heating indicated that this type of heating would help overcome problems associated with working in the cold especially those caused by cold extremities, i.e. cold hands and feet.

In addition to suggestions from respondents concerning potential applications of auxiliary heating the possibility of overcoming cited objections (such as safety hazard, bulkiness, etc.) has been identified.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the help and cooperation of all of the officers and other ranks of the Canadian Forces who participated in the administration and completion of the questionnaires.

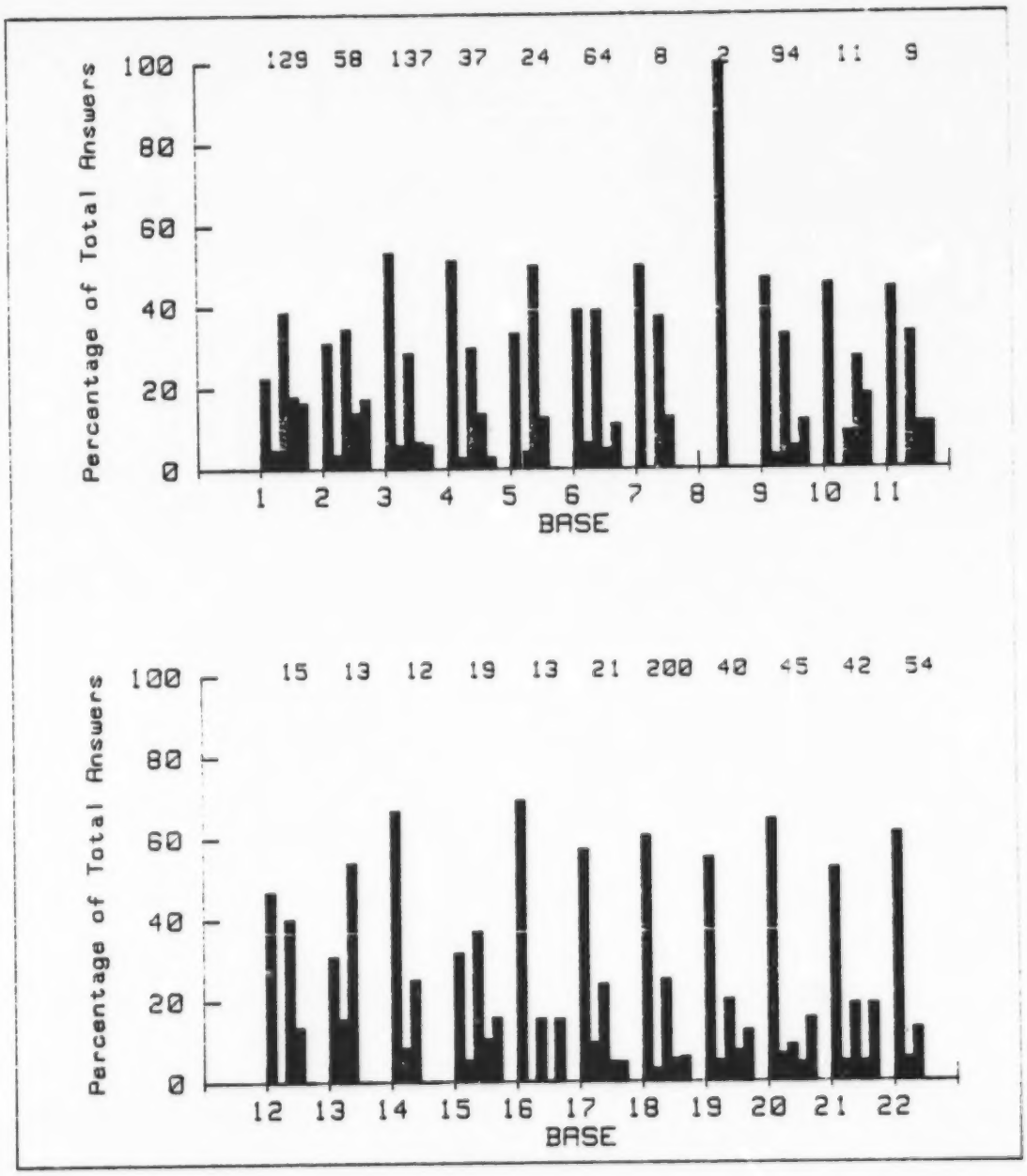

Figure 1: Answers to the question "Would the addition of auxiliary heating to your clothing or equipment have helped you to overcome this problem?" are shown as a percentage of the total answers at each Base. Totals are shown at the top of each group of columns. The Bases are identified by numbers on the abscissa (Appendix 3). The columns of each histogram indicate the answers "yes", "yes and no", "no", "confused" and "no answer", going from left to right in each cluster.

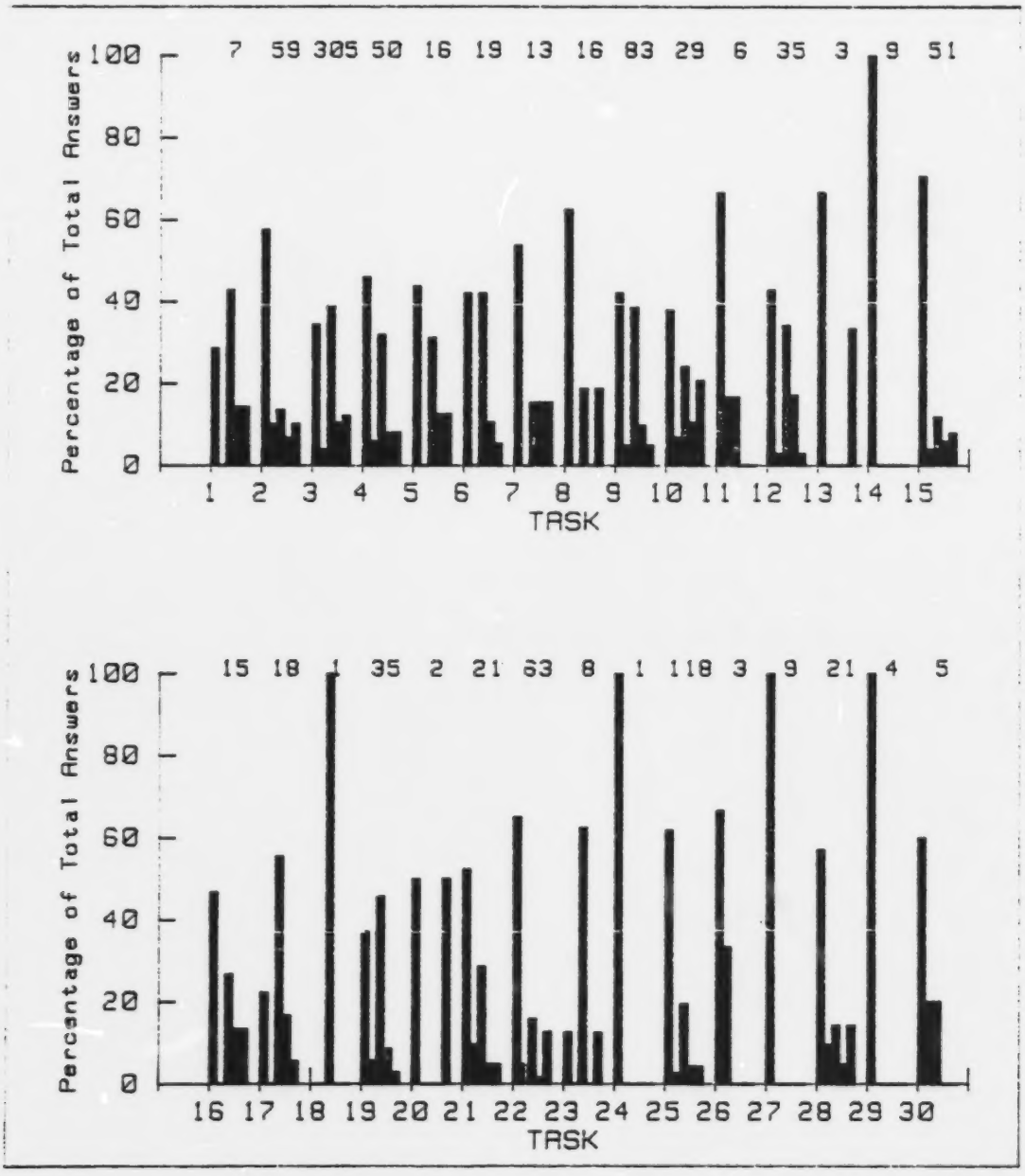

Figure 2: Answers to the question "Would the addition of auxiliary heating to your clothing or equipment have helped you to overcome this problem?" are shown as a percentage of the total answers for each task. Totals are shown at the top of each group of columns. The tasks are identified by numbers on the abscissa (Appendix 4). The columns of each histogram indicate the answers "yes", "yes and no", "no", "confused" and "no answer", going from left to right.

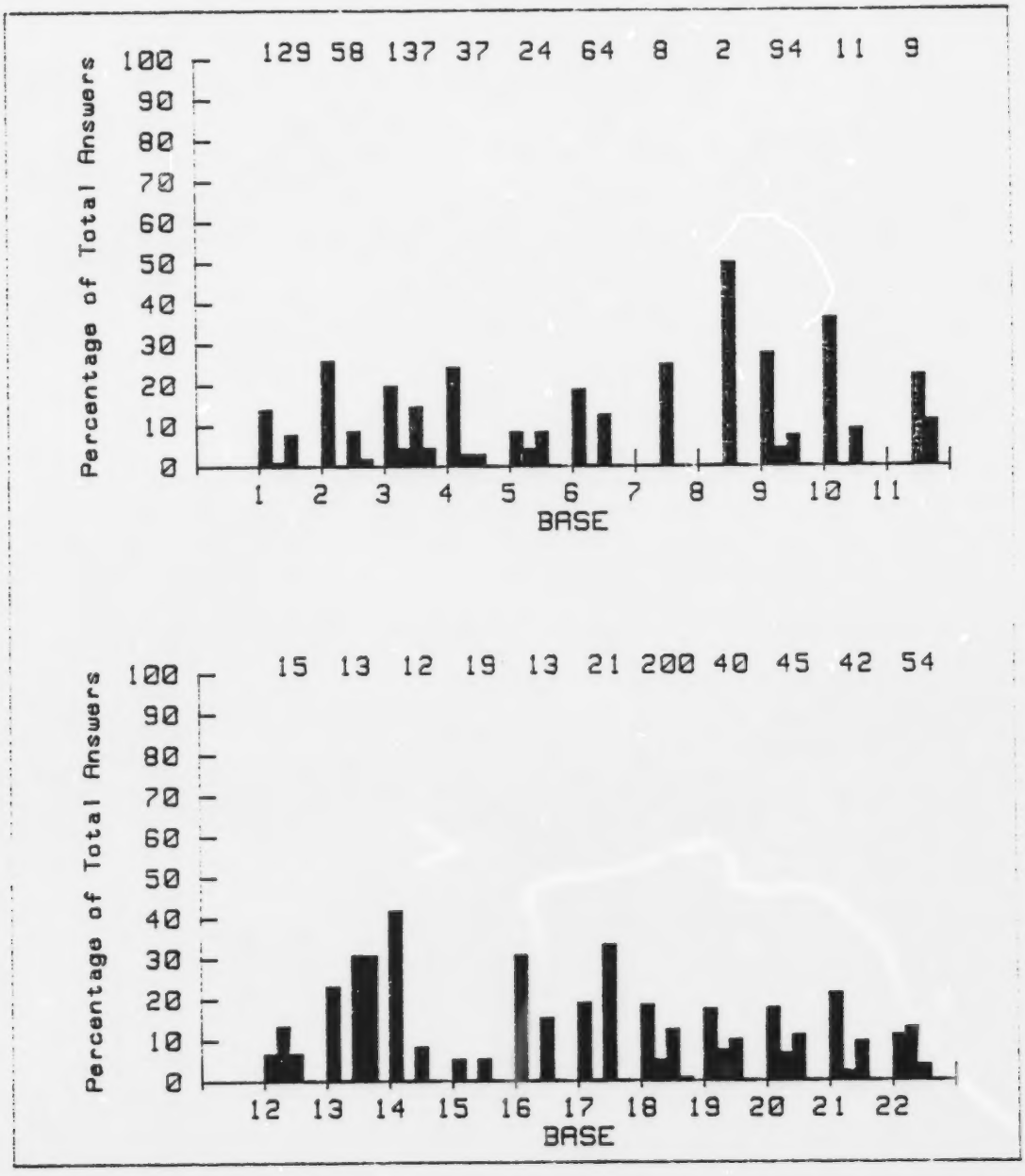

Figure 3A: Answers to the question "Which areas would be helped by auxiliary heating?" are shown as a percentage of the total answers at each Base. Totals are shown at the top of each group of columns. The Bases are identified by numbers on the abscissa (Appendix 3). The columns of each histogram indicate the answers "hands", "feet", "hands and feet" and "face", going from left to right.

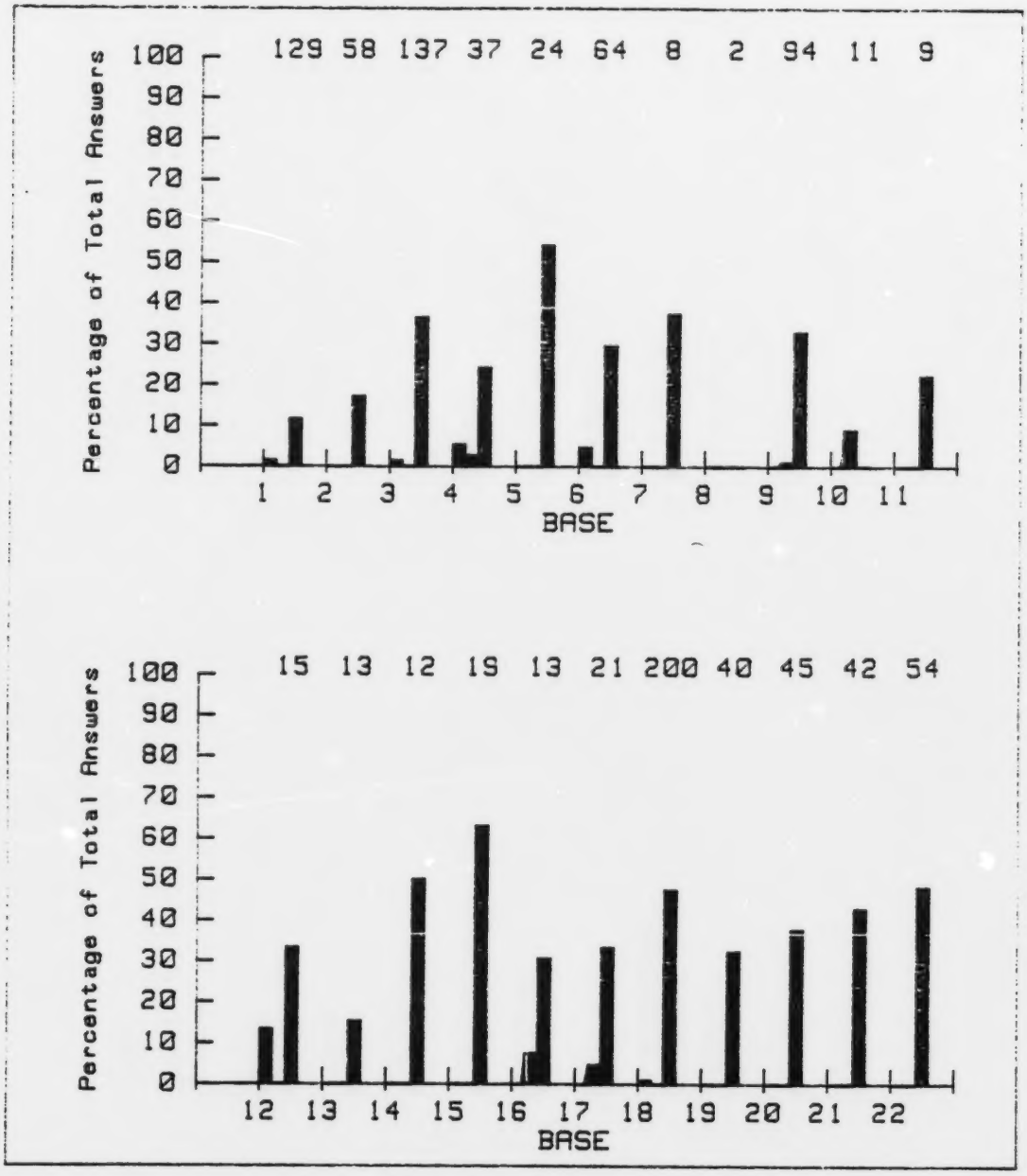

Figure 3B: This figure is similar to Figure 3A except that the columns of the histograms indicate the answers "arms or legs", "torso" and "not specified", going from left to right.

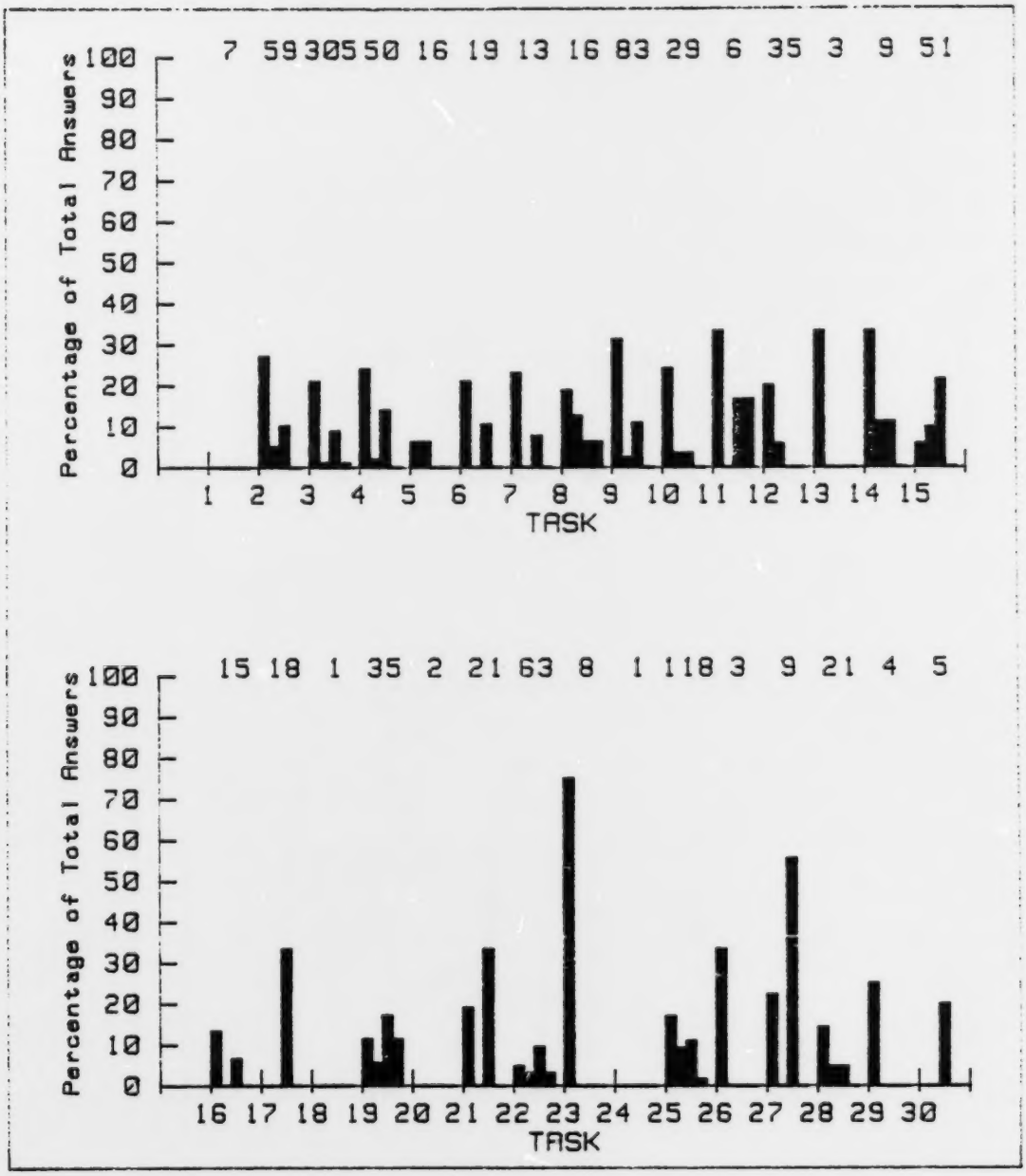

Figure 4A: Answers to the question "Which areas would be helped by auxiliary heating?" are shown as a percentage of the total answers for each task. Totals are shown at the top of each group of columns. The tasks are identified by numbers on the abscissa (Appendix 4). The columns of each histogram indicate the answers "hands", "feet", "hands and feet" and "face", going from left to right.

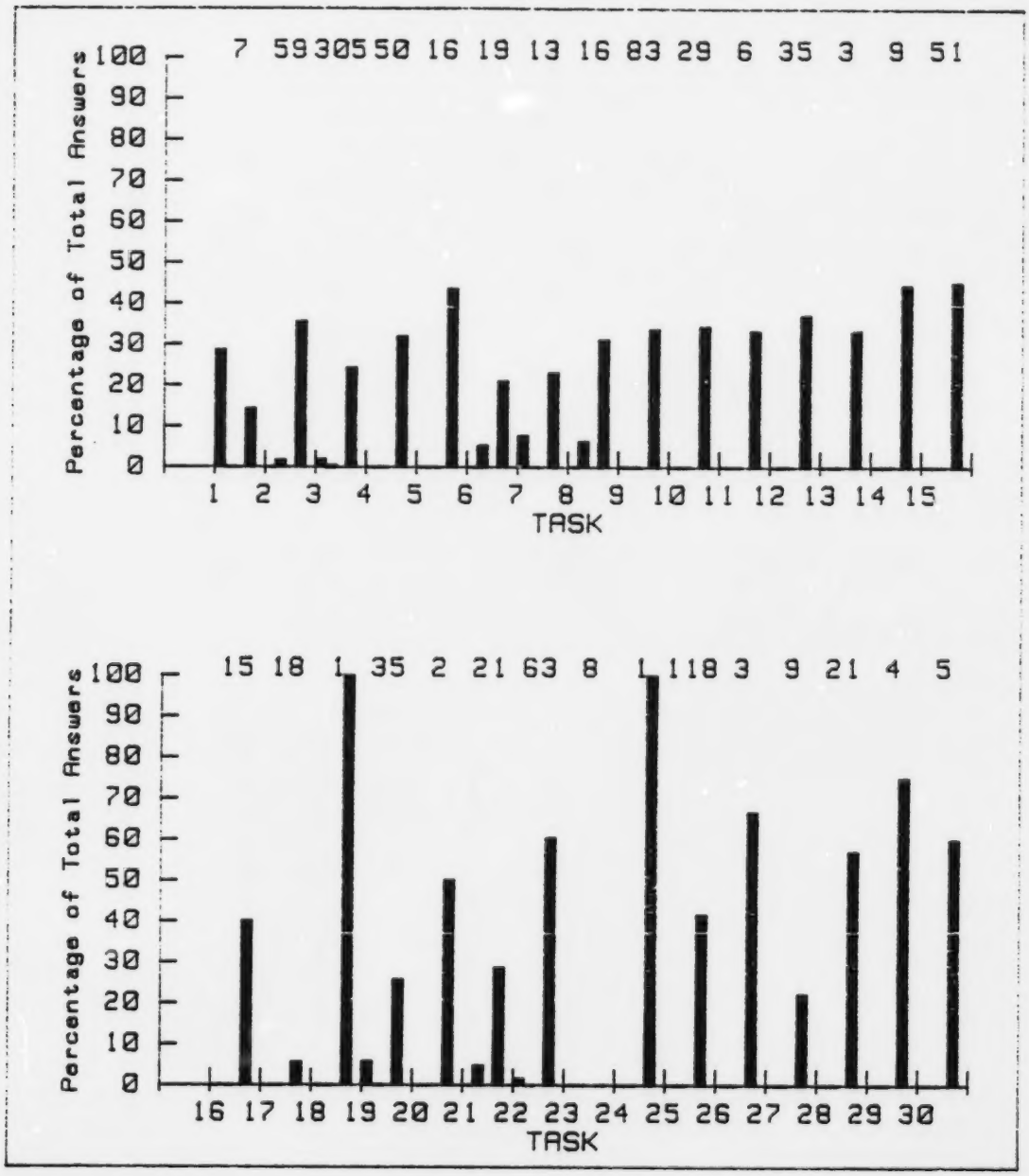

Figure 4B: This figure is similar to Figure 4A except that the columns of the histograms indicate the answers "arms or legs", "torso" and "not specified", going from left to right.

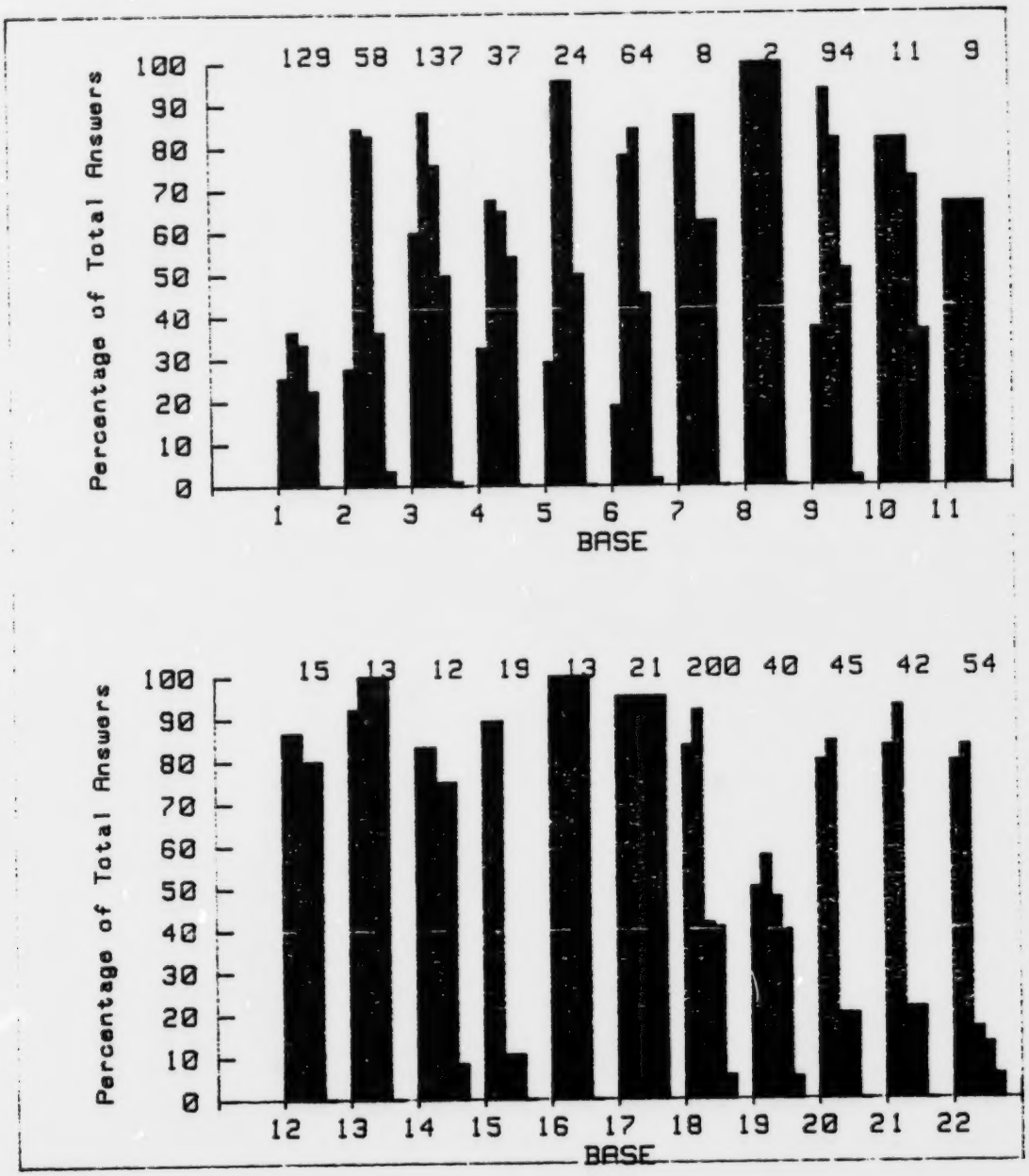

Figure 5: Authors' interpretations of the questionnaires regarding the type of auxiliary heating that would help in various situations are shown as a percentage of the total in each category at each base. Totals are shown at the top of each group of columns. The bases are identified by numbers on the abscissa (Appendix 3). The columns of each histogram indicate the answers "electrical", "chemical", "hot air", "infrared" and "other", going from left to right.

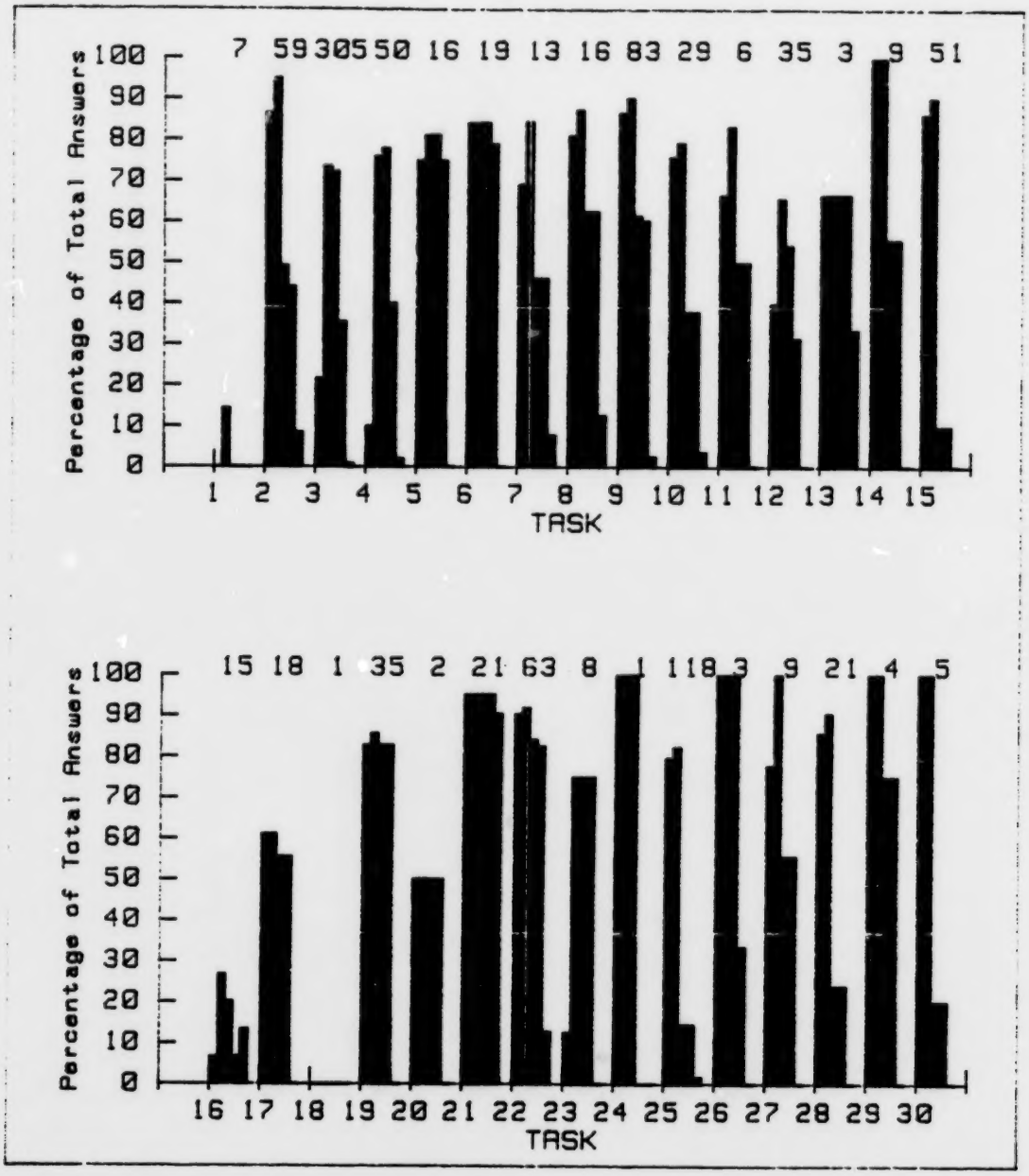

Figure 6: Authors' interpretations of the questionnaires regarding the type of auxiliary heating that would help in various situations are shown as a percentage of the total in each category for each task. Totals are shown at the top of each group of columns. The tasks are identified by numbers on the abscissa (Appendix 4). The columns of each histogram indicate the answers "electrical", "chemical", "hot air", "infrared" and "other", going from left to right.

APPENDIX 1

DREO 3613B-1 (PSD)

Q U E S T I O N N A I R E

1. This questionnaire is being circulated to gather information on problems that are caused or aggravated by cold exposure especially to the hands or feet during cold weather operations.

2. The information obtained will be used in planning future research activities in protective clothing and equipment at Defence Research Establishment Ottawa (DREO) and development activities at Directorate of Clothing, General Engineering and Maintenance (DCGEM). Since Canada has agreed to undertake a study for NATO regarding auxiliary heating of the hands and feet, information regarding its possible uses is also requested. (See Question 7.)

3. Please confine your answers to activities encountered in military operations performed out-of-doors which were hampered by cold exposure, e.g. during field exercises, training, maintenance, construction, etc.

4. Separate equestionnaires should be used for different activities which were influenced by cold exposure. If additional copies are required and cannot be duplicated locally, please contact:

Dr. S.D. Livingstone
Environmental Protection Section
Defence Research Establishment Ottawa
Department of National Defence
Ottawa, Ontario K1A 0Z4
Phone: (613) 596-9303

5. Completed questionnaires should be returned to the individual handing them out for forwarding to DREO.

Q U E S T I O N N A I R E

1. Activities influenced by cold exposure (use extra page if required):
   Please describe (1) type of operation (e.g. aircraft maintenance, surveillance in closed down tank...);
   (2) problem (e.g. cold hands, extensive shivering, extreme discomfort...); and
   (3) consequences (e.g. work not completed, slowdown, injury, morale...).

2. Approximate frequency of activity in cold:

Daily_____ Weekly_____ Monthly_____

3. Part of body most affected: Hands____ Feet____ Face____

Other:

4. Environmental conditions at time of activity: (where actual environmental data is not available please estimate range, e.g. temp -20 to -30°C or wind 10-20 kph).

Temperature:_____
Wind:_____
Precipitation: Rain____ Snow____

Any other conditions related to the weather pertinent to this activity:

5. List current protective clothing usually worn for this task:

Are items of clothing and other protective equipment adequate for this task?

Yes_____ No_____

If no what changes would you recommend?

6. Describe the measures taken by you presently to accomplish the task/activity:

How effective is the solution?

Do you have any additional suggestions for improving the situation?

7. Would the addition of auxiliary heating to your clothing or equipment (e.g. methods of heating hands, face, feet, etc.) have helped you to overcome this problem?

If so how?

If not why?

8. During task, do personnel have access to:

(1) Warm building or heated tent? Yes____ No____

(2) Other heat? Yes____ No____

(3) Power Source? Yes____ No____

9. How adequate is your shelter (e.g. building, vehicle, tent, etc.)? (Answer only if applicable to the problem.)

What changes do you recommend?

10. Other - Please add any comments you consider relevant to this problem:

11. The following information is requested so that follow-up, if necessary, can be done; however if you wish to remain anonymous, only rank and classification need be supplied:

Name:

Rank:

Classification:

Address:

Phone Number:

12. Duties during task which was hampered by the cold exposure:

If you require additional information please do not hesitate to contact Dr. S.D. Livingstone.

APPENDIX 2

DREO COLD STRESS SURVEY

INSTRUCTIONS RE SUPERVISION OF QUESTIONNAIRES

Since it is important that the same guidance be given to each group receiving the questionnaires it is requested that the following words be READ ALOUD to each group after handing out the questionnaires:

" - Please read the introduction on the questionnaires which explains why the survey is being done.

- Most of the questions need no further explanation or emphasis.

- One point that should be emphasized as you begin is that you should decide on the activity which you are going to describe throughout the questionnaire you have. If there is another activity which you should also describe, ask for another questionnaire blank.

- Don't forget to describe all three aspects of question 1 (operation, problem, consequences). Your answers to this go on page 2.

- In question 4, you may have to estimate weather conditions.

- In question 5, please list ALL CF clothing worn (for example socks, boots, underwear, parka, shirt, sweater, windpants, gloves, etc.). If you had civilian clothing items on as well please give specific description (for example: Sears winter underwear, or thick wool civilian gloves, etc.).

- Please include ALL solutions you have found useful, in question 6. They are important to the success of the survey.

- In question 7 the term 'auxiliary heating' may be new to you. By 'auxiliary heating' is meant any type of external heat which can be supplied to the body. Examples are: stream of warm air, commercial chemical handwarmers (such as 'hotshots'), electrically heated gloves, etc., radiant heating, and so on. Please answer this question fully saying why or why not you think auxiliary heating would be helpful.

- In question 10, please add other comments that relate to the problem.

- In question 11, if you prefer to remain anonymous leave out your name and phone number but DO PUT DOWN your rank and classification so that people working with the questionnaires will have some information about your trade and experience.

- If you need extra paper, ask for blank sheets to attach to the form.

- When you finish your answers you are free to go. Please do not discuss the questionnaires with anyone else who will be writing questionnaire answers in a later group. We need all participants to give their own opinions. Once the scheduled questionnaire sessions are completed, feel free to discuss them in detail or even to request a supplementary copy for any important new items which arise from further thought and discussion.

- The defence scientists organizing this survey want me to thank you for your participation."

APPENDIX 3

NUMBERED LIST OF BASES RESPONDING TO
AUXILIARY HEATING QUESTIONNAIRE
(As used in Figures 1, 3A, 3B and 5)

1 - CFB Comox
2 - CFB Trenton
3 - CFB Winnipeg
4 - CFB Greenwood
5 - CFB Bagotville
6 - CFB Cold Lake
7 - CFB Wainwright
8 - CFB Gagetown
9 - CFB Namao
10 - CFB Inuvik
11 - CFB Halifax
12 - HMCS Skeena
13 - HMCS Athabaskan
14 - CFS Alert
15 - CFB Chilliwack
16 - CFB Kingston
17 - St. Margarets
18 - CFB Calgary
19 - CFB Petawawa
20 - CFB Victoria
21 - CFB Shilo
22 - Quebec Citadel

APPENDIX 4

NUMBER DESIGNATORS OF TASKS USED IN ANALYSIS OF QUESTIONNAIRES AND IN PREPARATION OF FIGURES 2, 4A, 4B and 6

1 - marine rescue
2 - telecom. repair
3 - aircraft line crew
4 - refueller
5 - snow clearance
6 - loading and unloading
7 - base transport
8 - pilot
9 - vehicle maintenance
10 - construction
11 - indoor work
12 - weapons tech
13 - photographer
14 - military police
15 - sentry
16 - POL handler
17 - base defence force
18 - search and rescue
19 - ship training and duties
20 - firefighter
21 - satellite tracker
22 - armored vehicle crew
23 - cook
24 - paratroop
25 - foot soldier
26 - air defence
27 - resupply and supply
28 - artillery
29 - aircrew
30 - medical

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13. ABSTRACT

In order to investigate the requirement for auxiliary heating by the Canadian Forces, a questionnaire was administered to approximately 1500 CF personnel with experience working outdoors in cold weather. In addition to analyzing the respondents' actual replies, the authors also interpreted the completed questionnaires regarding the need for auxiliary heat. It was concluded that auxiliary heating would be beneficial to more than 50% of personnel with problems associated with working in the cold and that most of these problems were due to cold extremities (hands and feet).

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COLD WEATHER

CLOTHING

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